Distr.
GENERAL

UNEP/CBD/SBSTTA/7/7
20 September 2001

ORIGINAL: ENGLISH

CONVENTION ON BIOLOGICAL DIVERSITY

SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE
Seventh meeting
Montreal, 12-16 November 2001
Item 4 of the provisional agenda*

MAIN THEME: FOREST BIOLOGICAL DIVERSITY

Consideration of specific threats to forest biological diversity: (a) climate change, (b) human-induced uncontrolled forest fires, (c) impact of unsustainable harvesting of non-timber forest resources, including bushmeat and living botanical resources

Note by the Executive Secretary

Executive summary

The present note has been prepared in response to decision V/4 of the Conference of the Parties, in which it requested the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to focus on three specific threats to forest biological diversity related to climate change, human-induced uncontrolled forest fires and unsustainable harvesting of non-timber forest resources, and, in particular, to identify ways and means through which to mitigate the adverse impacts of these factors.

Drawing on literature reviews, given separately as information documents, the note synthesizes information on the description of these factors, their causes and impacts on forest biological diversity. The note also presents proposals for options to integrate conservation and sustainable use of forest biological diversity with respect to the provisions of the United Nations Framework Convention on Climate Change; proposals for activities and options to address the negative impacts of forest fires and unsustainable harvesting of non-timber forest resources on forest biological diversity.

Suggested recommendations

1. The Subsidiary Body on Scientific, Technical and Technological Advice may wish to consider the proposed options for the integration of conservation and sustainable use of forest biological diversity with respect to the provisions of the United Nations Framework Convention on Climate Change (in section

* UNEP/CBD/SBSTTA/7/1.

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II D), activities and options to address the negative impacts of forest fires (in section III F), and options on how to mitigate the impacts of unsustainable harvesting of non-timber forest resources on forest biodiversity (in section IV C), for possible inclusion in the expanded programme of work on forest biodiversity.

2. More specifically, the Subsidiary Body may wish to recommend that the Conference of the Parties, at its sixth meeting:

(a) *Invite* the United Nations Framework Convention on Climate Change, the Intergovernmental Panel on Climate Change (IPCC), the International Geosphere-Biosphere Programme (IGBP) in the context of its Global Change and Terrestrial Ecosystems global transect programme, and the Millennium Ecosystem Assessment to enhance collaboration in the research and monitoring activities on forest biological diversity and climate change, and explore possibilities of establishing an international network to monitor and assess the impact of climate change on forest biological diversity;

(b) *Invite* the Food and Agriculture Organization of the United Nations, the International Tropical Timber Organization and the Global Fire Monitoring Center, and other relevant organizations to include forest biodiversity in their assessments of fire impacts; explore possibilities for joint work programme with the Convention on Biological Diversity, including, *inter alia*, fire impact assessments, development of guidelines in fire management, and community based approaches in fire prevention and management; and report on progress to the Subsidiary Body on Scientific, Technical and Technological Advice prior to the seventh meeting of the Conference of the Parties to the Convention on Biological Diversity;

(c) *Establish* a bushmeat task force to facilitate development of a strategic plan of action to reduce unsustainable hunting of endangered species for bushmeat, taking into account the need to find alternative sources of protein and income for the rural populations concerned, and *request* the Executive Secretary, in collaboration with the secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the range States, other Parties and relevant organizations and stakeholder groups to participate in this task force;

(d) *Request* the Executive Secretary, in collaboration with other members of the Collaborative Partnership of Forests and its network, to explore possibilities to enhance the integration of non-timber forest resources in the forest inventory and management, and to report on progress to the Subsidiary Body on Scientific, Technical and Technological Advice prior to the seventh meeting of the Conference of the Parties;

(e) *Invite* all the members of the Collaborative Partnership of Forests and its network to contribute to this work, including by reporting their relevant activities to the Subsidiary Body on Scientific, Technical and Technological Advice and for the discussion through the clearing-house mechanism of the Convention on Biological Diversity;

(f) *Request* the Executive Secretary to enhance collaboration with the members of the Collaborative Partnership of Forests, and other organizations mentioned in the recommendations, and to report on achievements to the Subsidiary Body on Scientific, Technical and Technological Advice when it considers forest issues or sustainable use;

(g) *Urge* Parties to the Convention and other Governments to consider the options proposed in the present document for inclusion in their programmes and plans for the conservation and sustainable use of forest biological diversity, and report on the results of such consideration to the Conference of the Parties at its future meetings when it considers forest-related issues.

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I. INTRODUCTION

1. In paragraph 11 of its decision V/4, the Conference of the Parties requested SBSTTA to consider the impact of climate change on forest biological diversity and to prepare scientific advice in order to integrate biological diversity considerations, including biological diversity conservation, into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto Protocol. In paragraphs 12 and 14 of the same decision, the Conference of Parties further requested SBSTTA, respectively:

(a) To consider the causes and effects of human-induced uncontrolled forest fires on forest biological diversity and propose possible approaches to address negative impacts; and

(b) To consider the impact of, and propose sustainable practices for, the harvesting of non-timber forest resources, including bushmeat and living botanical resources.

2. In order to assist the Subsidiary Body in its consideration of the matter, the Executive Secretary has prepared the present note on the basis of in-depth technical papers on climate change, human-caused uncontrolled forest fires and impacts of unsustainable harvesting of non-timber forest resources on forest biological diversity, which will be made available as information documents. The present note also supplements the report (UNEP/CBD/SBSTTA/7/6) and other documents produced by the Ad Hoc Technical Expert Group on Forest Biological Diversity.

3. The importance of the three specific threats under consideration has increased in the last few decades as a result of increased human influence on the biosphere. They also have several interlinkages with each other, as well as to many human activities. Forests have become more sensitive to forest fires as a result not only of climate change, but also of improper logging practices and suppression of natural fire regimes. Harvesting of non-timber forest resources has become unsustainable because of easier access to forests through new road networks and as a result of the transition from subsistence to commercial harvesting. Fragmentation caused by various human activities exacerbates the impacts of forest fires or species-specific over-exploitation on biota and makes recovery more difficult.

4. The increase in human-induced uncontrolled forest fires and unsustainable harvesting of non-timber forest resources are both essentially related to the underlying causes of forest biological diversity loss, both in terms of deforestation and changes in the forest qualities. Direct and underlying causes of forest biodiversity loss have been addressed in detail by the Ad Hoc Technical Expert Group on Forest Biological Diversity.

II. FOREST BIOLOGICAL DIVERSITY AND CLIMATE CHANGE, IN PARTICULAR, IMPACTS OF CLIMATE CHANGE ON FOREST BIOLOGICAL DIVERSITY

A. Introduction

5. Global climate change represents an especially disturbing threat to forest biological diversity for several reasons. Firstly, because impacts of climate change will potentially be felt in almost all forest regions. Secondly, the capacity of many forest-dwelling species and forest ecosystems to adapt to changed climatic conditions has been greatly diminished by fragmentation with reduced gene flow and migration options, due to recent land-use patterns. Thirdly, the nature and scale of impacts are complex and require a comprehensive and coordinated response at regional levels and globally.

6. The impact of climate change on forest biological diversity is often overshadowed by the effect of human-induced modifications of terrestrial ecosystems that are responsible for major losses in biodiversity in many forest ecosystems. This has created difficulties in being able to discriminate between the more immediate effects of natural-resource modification by humans and the longer-term - and in many cases more subtle - effects of climate change. Despite conflicting accounts about the nature and extent of the impact of climate change on biodiversity, there is a general understanding that biodiversity will decline worldwide under most climate-change and global-change scenarios (e.g. Bazzaz 1998, Easterling et al. 2000).

7. The interlinkages between climate change and biological diversity were addressed by SBSTTA at its sixth meeting, in March 2001. In its recommendation VI/7, SBSTTA noted those interlinkages and decided to promote, on the basis of the ecosystem approach, their wider assessment. It decided to carry out a pilot assessment to prepare scientific advice to integrate biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto Protocol, and, for this purpose, established an ad hoc technical expert group. This pilot assessment will include a more detailed review of the interlinkages between climate change and biological diversity in forest ecosystems.

8. This chapter describes the main impacts of climate change on the forest biological diversity (section B), outlines the interlinkages between conservation and management of forests and carbon sequestration (section C), and suggests some research activities and guiding principles for actions to mitigate adverse effects of climate change (section D).

B. Impact of climate change on forest biological diversity

1. Genetic level

9. At present there are few accounts of impacts of climate change on genotypes. On a longer time scale, warming could result in genetic changes because natural selection will likely favour, e.g., lowland genotypes in mountainous sites where they are currently rare. Forest fragmentation due to land-use changes but also induced under global warming may lead initially to a loss in genetic variability resulting from reduced natural gene flow. Genetic variability is also lost by local extinctions of small isolated populations. Changes in the amount of pollinators or animals dispersing seeds and fruits will have effects on the genetic structure of host plant populations.

2. Species level

10. *Plants*: A plant's ability to move to new habitats or regions under pressure from changing climate will vary according to species and its ecological group. For example, such features as capacity to fix atmospheric nitrogen, resist and tolerate desiccation and low nutrient levels or disperse rapidly will play a major role in vegetation response to climate change. Increase in atmospheric carbon dioxide may change the competitive balance between species that differ in various biological characteristics, such as photosynthetic pathways. Elevated levels of carbon dioxide are likely to have the most notable effect on species composition in the presence of nitrogen deposition, which has increased markedly in last decades.

11. Although there will be regional differences in the nature and extent of plant species response to climate change, a general concept is that plant species diversity will decline overall. For example, climate change in combination with increasing fragmentation of forests is likely to cause extinction of many species. More mobile, widespread, genetically variable species with short generation times will be best able to adapt and survive accelerated climate change. Species with restricted distributions, especially slow

growing late successional species or those with restricted seed dispersal are especially vulnerable to climate change (Kirschbaum *et al.* 1996). It is worth noting that any form of new disturbance or environmental perturbation is likely to have major adverse effects on forests which are species-rich in restricted-range endemics (Lovett *et al.* 2000).

12. *Vertebrates:* Food resources for a number of herbivorous mammals are in many cases restricted to certain plant species that may be under threat with climate change. The decline in abundance of these resources may have great impact on both herbivores and consequently their top predators. With forest fragmentation the range distribution of many forest-dwelling mammals has decreased dramatically. This process is almost certain to accelerate with human population pressure, which makes these ecosystems more susceptible to climate change.

13. Impacts on birds may already be underway with a trend detected in the movement of ranges towards higher latitudes in Antarctica, Australia and North America. Increased forest fragmentation under global warming may lead to variable responses in bird species richness depending on forest type and local climate. The long-term loss of habitat will lead to marked species decline. Migration patterns are almost certain to change for many species under a global warming scenario where increased temperatures significantly affect over-wintering resources on route to breeding habitats.

14. Because many amphibians and reptiles are adapted to specific forest habitats and are susceptible to desiccation, any change leading to a drying out of habitat, for example with increasing seasonality, is very likely to lead to a decline in their populations and later also in species number. In many countries, the number of amphibians and reptiles in red lists is already high.

15. *Invertebrates:* Many insect species are highly specialized in their habitat requirements. The interactions between species are often complex, and they can be broken down because of anthropogenic changes in forest ecosystems. When changing the plant constituency of forest, climate change will lead to changes in resource availability (quantitative changes in abundance of host species or other important ecological elements, such as amount of decaying wood of particular size and age). It is evident that rare specialist insect species will be lost and more widespread species become more common. Overall species and genetic diversity will decrease, and species of plant or invertebrate dependent on the rare species will also be lost.

16. With global warming, the disturbance patterns caused by insects may change substantially, especially for those insects whose distributions depend largely on climate. Climate change may already be influencing life cycles of some harmful insects. Climate change impact on insects is likely to differ between temperate and tropical regions. According to Coley (1998), in contrast to the temperate zone, most herbivory in the tropics occurs on ephemeral young leaves. As a consequence, plant/herbivore interaction in the tropics may be more susceptible to climate change than in the temperate region. Climate change is expected to increase the range of many arthropods and may make many of them potential pests in new environments.

3. Ecosystems and biomes

17. Earlier models that forecasted shifts in forest biomes or ecosystems as intact entities as a response to climate change are now no longer considered useful. The reason is due to the differential

response of species and functional types 1/ to changing environment in which biomes and ecosystems are likely to lose ecological integrity. For this reason, forest communities and forest ecotones are likely to become blurred as the range distributions of species and functional types readjust to new environments (Neilsen, 1993). Migration rates between different plant and animal groups differ regionally with geographic isolation mechanisms and with barriers to certain groups arising through increased habitat fragmentation due to land-use and climate change. Most models suggest that increases in invasive weedy species, especially exotics, associated with regional shifts in pests of forest and agricultural crops may accompany biodiversity decline in the scenarios presented by the IPPC. Regional differences in ecosystem response restrict, however, generalization about the invasive potential of species.

18. Climate change predictions by Working Group II of the Intergovernmental Panel on Climate Change report (IPCC 2001), concludes that forest fires will become an increasing problem in many forest ecosystems. It is expected that large forest areas in Latin America will be affected as a result of projected changes in climate (see chapter III below). Climate change could add an additional stress to the adverse effects of continued deforestation of the Amazon rainforest as a result of reduced rainfall and runoff within and beyond the Amazon basin. This impact could lead to biodiversity losses, and affect the global carbon cycle. In boreal regions, an increase in temperature, accompanied by decreases in soil moisture, could lead to a substantial reduction in peat formation in high latitudes. Reduced soil moisture during the summer will increase drought stress and the incidence of wildfires.

19. Also earlier climate modelling and assessment suggest that a climatic warming will lead to large changes in the northern latitudes (e.g. Cramer et al 2000). Areas of northern taiga and tundra woodland are predicted to be replaced by more productive boreal forests as climate warming occurs, while some dry southern boreal areas may become savannahs (Thompson et al. 1997). Changes include also invasions by southern species increasing impacts of pathogens, altered fire regimes, and various natural disasters caused by episodic storm events (Kellomäki 2000). The possible destruction of permafrost accompanying climate change and human land use change may result in major landscape degradation.

C. Forest management and carbon sequestration

20. The Kyoto Protocol to the United Nations Framework Convention on Climate Change defines reduction targets for greenhouse gas emissions by Annex I countries. 2/ Net changes in greenhouse-gas emissions by sources and removals by sinks resulting from certain direct human-induced land-use change and forestry activities can be used to meet these commitments. Relevant activities are afforestation, reforestation and deforestation ("ARD") that give rise to verifiable changes in carbon sequestration considered since 1990. The Kyoto Protocol also makes room for any additional land use, land-use change, and forestry (LULUCF) activities that may be agreed by the Conference of Parties to the Convention. Examples being discussed include forest or crop management practices that increase carbon sequestration.

21. The inclusion of land use, land-use change, and forestry (LULUCF) activities in accounting for net emissions could, with appropriate safeguards, potentially promote the conservation and sustainable use of forest biological diversity. However, there are also risks of negative impacts on forest biological diversity and related goods and services (IPCC 2000). For this reason, the goals and objectives of the Convention

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1/ Functional types are sets of organisms showing similar responses to environmental conditions and having similar effects on the dominant ecosystem processes. This is an extension of an earlier definition on plant functional types, representing species or groups of species that have similar responses to a suit of environmental conditions.

2/ These are industrialized countries, including developed countries and countries with economies in transition.

on Biological Diversity and biodiversity-related agreements should be taken into account when considering LULUCF activities for mitigating the impacts of climate change.

22. The Kyoto Protocol requires monitoring of greenhouse gas removals and emissions from human-induced deforestation, afforestation and reforestation since 1990. Assessment of emissions and of climate impacts, especially on carbon sinks and sources, requires clear definition of deforestation and reassessment of the fate of carbon in such systems. For example, recent studies show that, whereas in temperate and boreal forests belowground carbon is highly significant relative to aboveground carbon this now appears less likely in many tropical forested lands apart from freshwater and mangrove swamp forests on deep peats. It is also now realized that most unmanaged forests have more biodiversity and carbon than managed (e.g., plantation) forests.

23. The clean development mechanism under Article 12 of the Kyoto Protocol provides for industrialized countries to undertake emission-reduction projects in developing countries. The Protocol does not specify, however, what land use change and forest projects will be allowed under the mechanism, thus leaving the way open for activities that may have uncontrolled impacts on forest biological diversity. A closer study of potential impacts is therefore needed in order to better define the implementation of the clean development mechanism.

24. Forest conservation and improvement of the sustainability of forest management are important means of mitigating the negative effects of an increase in the atmospheric concentration of carbon dioxide and the associated climatic change. International incentives to promote policy changes towards better forest conservation and more sustainable forest management should be strengthened within the Kyoto Protocol process and other relevant processes initiated since the 1992 United Nations Conference on Environment and Development (UNCED), since they may provide long-term, sustainable greenhouse gas mitigation options and other environmental services of local, regional or global importance (Koskela et al. 2000).

25. If tree plantations were to be included in the clean development mechanism as means of afforestation or reclamation of deforested or severely degraded land, it has to be ensured that plantation establishment does not directly or indirectly accelerate the deforestation or degradation of natural or semi-natural forests, for instance, by increasing the intensity of shifting cultivation or land-clearing for permanent agriculture, or cause social or economic disadvantage to the local people. Agroforestry systems with perennial crops, such as forest trees, fruit trees or estate crops, provides verifiable carbon gains, if established on land previously used for annual cropping or pasture, or on previously degraded land. Agroforestry should be considered an essential part of, or an alternative to, forest plantations especially if there is a serious land scarcity in the project area. Verification methods for carbon-balance benefits in agroforesty systems should be further developed (Koskela et al 2000).

26. Biomass fuels, such as firewood, charcoal and agricultural residues, provide a sustainable, renewable energy source when obtained from properly managed forests. The carbon burned in these fuels is sequestered in the re-growth of the plants. Carbon is thus recycled, and not added to the atmospheric stock, as in the case of fossil fuels. Fuelwood plantations can provide significant carbon gain, although the same reservation as for tree plantations.

D. *Proposed options for the integration of conservation and sustainable use of forest biological diversity with respect to the provisions of the United Nations Framework Convention on Climate Change and its Kyoto Protocol*

1. *Development of guiding principles for adaptation options* 3/

27. The following elements might be taken into account in the development of guiding principles for adaptation options:

(a) Preservation of the pool of natural species and genetic variability of forests at as high a level as possible in order to maintain the adaptability of forest ecosystems to consequences of climate change, both in protected areas and outside;

(b) Maintenance or establishment of connections between protected areas or natural ecosystems by creating ecological corridors or by maintaining appropriate ecological components in associated areas to allow natural migration of ecosystem elements;

(c) Reduction or removal of land-use related and other anthropogenic stresses as far as possible. In particular, avoid fragmentation of forest ecosystems caused by land-use, habitat quality loss, introductions of invasive alien species;

(d) Description of best management practices that will maintain or enhance adaptive capacity or resilience of ecosystems, e.g., establishment of wooded ecotones and buffer zones in order to allow ecosystem replacement;

(e) Restoration of degraded lands due to climate change;

(f) Proactive adaptation of patterns of sustainable land use as main ecological characteristics, such as moisture regime, productivity, fire regime of forest ecosystem is altered.

2. *Development of international joint research on the effects of climate change on biodiversity*

28. Widespread concern about biodiversity conservation and the likely impact of climate change indicates a need for closer cooperation and coordination at global level. Several international institutions are planning for a global network of sites for monitoring forest biological diversity and ecosystem response to environment change. It would be logical for such bodies to coordinate with IGBP. Such a joint programme would add synergy to global, international studies on the impact of climate change on biodiversity, and greatly assist in the further development of models such as the "dynamic global vegetation models" and "global circulation models". As with the IGBP programme, the Millennium Assessment approach is consistent in many ways with the need to integrate both biophysical and socio-economic aspects of biodiversity management. Therefore, international joint research on the effects of climate change on biodiversity could be developed through:

3/ This issue was addressed in the note by the Executive Secretary on biological diversity and climate change, including cooperation with the United Nations Framework Convention on Climate Change (UNEP/CBD/SBSTTA/6/11) prepared for the sixth meeting of SBSTTA, in particular in annex II ("Overview of the interlinkages between biological diversity and climate change").

(a) The establishment of an international network to monitor and assess the impact climate change on forest biological diversity in cooperation with the IGBP/GCTE global transect programme, 4/ which is collecting wide-ranging environmental data of potential value for modelling the ways in which biological diversity responds to climate change;

(b) Enhanced collaboration between IGBP and the Millennium Assessment

3. Research priorities on interlinkages between carbon balance, biodiversity and forestry measures

29. Particular emphasis could be placed on the following elements:

(a) The integrated effects of an increasing atmospheric carbon-dioxide concentrations and global warming on tropical forests is poorly understood, and research is needed for estimating the effects of climate change on the tropical forest biodiversity and carbon sink.

(b) New innovative methods for tree-plantation management should be supported by relevant research; this includes the use of fast-growing trees as protection for indigenous trees so as to diversify man-made plantation forest ecosystems and to facilitate the process of gradual rehabilitation of natural tropical forests. Associated increases in carbon sequestration should also be clarified.

(c) The carbon sequestration potential of tropical drylands and their likely reaction to climate change should be more intensively studied; in particular, the traditional management of trees in dryland agro-forestry systems and the use of indigenous trees for farmland rehabilitation in arid and semi-arid areas.

(d) The functioning and carbon balance of agroforestry systems is poorly understood. Research is needed so as to enable better evaluation of their carbon sequestration potential and other environmental services.

III. HUMAN-INDUCED UNCONTROLLED FOREST FIRES

A. Introduction

30. The present chapter describes briefly natural and prescribed fires (section B), uncontrolled fires and their causes (section C), main impacts of human-induced fires on forest biological diversity and forest ecosystem functions (section D). Based on major findings, a number of proposals to address the negative impacts of these fires are presented (section E).

B. Natural and prescribed forest fires

31. Forest fires occur either because of anthropogenic or natural causes. The majority of fires around the globe are caused by human activity. Lightning is probably the most common natural cause of fire. In the tropics, natural fires occur every dry season in savannah woodlands, monsoon, dry semi-deciduous

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4/ The IGBP/GCTE global transect study is being developed as a tool for global change research. The transects consist of a set of study sites of the order of 1000 km in length and wide enough to encompass several grid cells of global models. Each transect has been designed to sample variation of major environmental factors as it influences terrestrial ecosystem structure and functioning (e.g. carbon and nutrient cycling, biosphere-atmosphere gas exchange and hydrologic cycling). In all 15 transects have been established to date.

forests, tropical pine and bamboo forests. Wildfires in most undisturbed, tall, closed-canopy, tropical rain forests are considered virtually impossible because a moist microclimate, moist fuels, low wind speeds and high rainfall create nearly non-flammable conditions.

32. Fires are a natural and important part of disturbance regimes in many temperate and boreal forest ecosystems. Several millions of hectares of boreal forest are burned every year, often with high intensity. Forest flammability is also high in many areas in the Mediterranean basin and many plant communities are fire-prone and adapted to regular fires.

33. Absence of fire in forests and woodlands, where fire is part of the ecological process of regeneration, can have a deleterious effect on biological diversity and its processes in the long term. In these ecosystems, species are adapted to a natural or anthropogenically influenced fire regimes, and can benefit from the effects of a fire. Prescribed burning is also often used as a management tool in these ecosystems. However, variation in fire frequency and intensity is great, and e.g. during longer drought periods natural wildfires or land-use fires can become uncontrolled and deleterious in their ecological impacts.

C. Uncontrolled forest fires in last decades and their causes

34. Globally, no reliable statistics about the annual distribution and extent of forest fires exist. However, the FAO in its latest decal forest resources assessment (FAO 2001) has included forest fire statistics for the first time, but they are not comprehensive. There are no data for Africa, few for Asia, Oceania, and the Americas, but a complete dataset for Europe. Some of the countries badly affected by fires, such as Indonesia and Brazil, have no fire statistics presented in FAO Forest Resources Assessment 2000. Obtaining global forest fire statistics is a difficult task; often Governments in developing countries do not have sufficient human or technical resources to carry out the assessment. There is also a need for increased clarity on the type of vegetation burned, and for improved information on the degree of the fire damage caused to forest.

35. A combination of human activity, fuel type and climate accounts for the majority of vegetation fires. While the weather conditions that create drought and influence the flammability of forests are quite natural, the factors that have turned these events into a disaster are predominantly human-made. In the past two decades, extended and frequent droughts coupled with increased pressures on land and unsustainable forest use, especially in the tropics, have led to an increase in catastrophic fire events, the worst fire years being 1983/84 and 1997/98. In recent years (1997/98 and 2000) in particular, forest fires have been severe and widespread in Africa (Kenya, Rwanda), Asia (Indonesia, Papua New Guinea, Mongolia, Russia), Australia, Europe (Russia and the Mediterranean area, especially Greece, Italy and Spain), Latin and Central America (Brazil, Colombia, Peru, Central America, Mexico), and North America (United States of America and western Canada). During these fires also large forest areas, which burn only very seldom, were devastated (IUCN/WWF 2000). Estimates suggested that fires in 1997/98 impacted as much as 20 million hectares of forest worldwide. 5/

36. The main direct anthropogenic causes of forest fires are (cf. UNEP/CBD/SBSTTA/7/INF/1):

(a) Land clearing with fire and fires connected with resource extraction;

(b) Arson;

5/ A more detailed description for fires in 1997-2000 can be found in “The Global Review of Fires” (IUCN/WWF 2000). See also fire season summaries on the Global Fire Monitoring Centre website.

(c) Accidental or escaped fires;

(d) Increased amount of flammable fuel in the forests due to logging or fire suppression.

37. Land-development strategies, such as ranching or pulp or oil palm plantations, use fire for land preparation and have significantly contributed to forest fires in recent years. In addition, smallholder farmers use fire in the preparation of land and for slash-and-burn agriculture. These land-clearing fires often escape the intended area, especially during drought, and burn nearby forests. Arson is a major cause of fire in many resource rich areas, where land is either scarce for agricultural production, and/or where there is resource conflict over tenure or access rights (Applegate et al. 2001).

38. In spite of their resistance to natural forest fires, tropical rain forests may become more susceptible to fire during severe droughts, as experienced during El Niño years. The general thinking now is that fire regimes in tropical rain forests, even those that are undisturbed or unlogged, have changed from one characterized by low-intensity, very infrequent surface fires to one in which fires are relatively frequent and of potentially high severity, so called deforestation fires (IUCN/WWF 2000). In tropical peat swamp forests, a third type of fire — the ground fire — can occur when peat layers ignite. In recent years, many of these peat-forest fires are human-induced and more severe than in previous times, because drainage of peatlands makes them particularly vulnerable.

39. The level of pre-fire forest disturbance has a strong correlation with susceptibility to and impacts of fire. In general, fire intensity and damage sustained is significantly higher in logged-over forest than in natural forest. One of the most important ecological effects of burning is the increased probability of further burning in subsequent years, as dead trees topple to the ground, opening up the forest to drying by sunlight, and building up the fuel load with an increase in fire-prone species. The most destructive fires occur in rain forests that have burned previously, and the importance of multiple fire events in the degradation of tropical rain forests is great.

40. In the Mediterranean area, many grazed, coppiced or burnt ecosystems are now abandoned or altered resulting in a general increase in the quantity and flammability of fuels. An additional significant factor has been the extensive establishment of pine and eucalyptus plantations. These highly flammable monocultures have sustained many of the large wildfires. An important element in the wildfire problem in the Mediterranean has been the unprecedented occurrence of arson; a vast majority of the fires can be deliberately set (Goldammer and Jenkins 1990).

41. In temperate and boreal forests of North America lightning, debris-burning and arson are consistently the three main causes of fires. Fire suppression during the last decades has left a large amount of deadwood in the forests, providing potential fuel for large-scale, very detrimental wildfires. In the Russian Federation, fire has long been used as a land-clearance tool. Nevertheless, political and economic crises are probably the main underlying causes of recent large-scale fires. For socio-economic reasons, people are turning to the forests for income, and hunting, fishing, illegal logging and collection of non-timber forest products such as berries and mushrooms have increased significantly, increasing the risk of accidental fires. Authorities believe that 70-85 per cent of fires are anthropogenic, and west of the Urals this figure rises even higher (IUCN/WWF 2000).

D Impact of forest fires on forest ecosystems and biodiversity

42. At a global scale, forest fires can influence the chemical composition of the atmosphere and the reflectivity of the Earth's surface. At the regional and local scale, forest fires change biomass stocks, alter the hydrological cycle with knock-on effects to marine systems such as coral reefs, reduce visibility to

near zero, impact plant and animal species functioning and detrimentally impact on the health and livelihood of the human population, especially those living in forests (IUCN/WWF 2000). Biomass burning is now recognized as a significant source of carbon dioxide and is generally considered to contribute between 20 and 40 per cent of total carbon dioxide emissions worldwide (IUCN/WWF 2000). It has been estimated that fires from all the world’s tropical forests in 1998 released 1-2 billion tons of carbon, which is equivalent to one third of the emissions from fossil fuel burning worldwide.

1. Impact on forest vegetation

43. Fire is an essential part of the regeneration of many forest and woodland ecosystems in natural conditions. It is nature's way of recycling nutrients, especially nitrogen. Fire and also reduces disease in the forest. Adaptations to fire can clearly be seen in the reproductive and regeneration traits of plants (CIFOR 2001a) in forest ecosystems under the natural fire regime.

44. Impacts of forest fires vary greatly according to the intensity, frequency and type of fire. In tropical forests, the surface fires, which are often deceptively small and slow moving, ignite the organic debris lying on the forest floor. The principal forest damage comes not through the destruction of organic matter on the forest floor, but through the heat damage of living tissue of tree stems and lianas, which eventually causes the death of these plants, often months or years later (Nepstad et al. 1999). Depending on the intensity of the fire, it can kill virtually all seedlings, sprouts, lianas and young trees because they are not protected by thick bark. Fires also have a significant negative impact on the seed-bank, seedlings and saplings, what makes recovery of the original species difficult (Woods 1989).

45. In tropical rain forests, the replacement of vast areas of forest with savannah-like grasslands is probably the most negative ecological impact of fires. That has happened after the deforestation fires of high intensity, which completely burns the forest leaving nothing alive and bare soil. These processes have already been observed in parts of Indonesia and Amazonia (Cochrane et al. 1999, Nepstad et al. 1999). In north Queensland in Australia, it has been observed that where the aboriginal fire practices and fire regimes were controlled rain forest vegetation started to replace the fire-prone tree-grass savannahs (Stocker 1981).

46. Most boreal conifers and broad-leaved deciduous trees suffer high mortality even at low fire intensities. Some pines have thicker bark, and old tall trees have often survived several fires. The disturbance regime of fire creates successional patterns responsible for the mosaic of age classes and plant communities, the pioneer phases being usually dominated by grasses, herbs and broad-leaved deciduous trees. Fire refuges exist in some parts of the forest on moist sites with local humidity, where fire may be absent for several hundred years. Fire refuges are vital to the forest because many species may survive only in such areas, and then supply a seed source to recolonize the burned areas (Ohlson et al. 1997). The ability of post-fire boreal forests to regenerate is lowered, if fire refuges have been burned by high-intensity fires.

47. The degree of expected recovery of the forest depends on the intensity of burning. For the undisturbed tropical primary forest, full recovery of the forest can be expected within a few years (Schindele et al. 1989). In lightly disturbed burnt forest, the potential for recovery is good, but not without the help of rehabilitation methods. In moderately disturbed burnt forest, it is unlikely that there would be

timber production for at least 70 years, and in heavily disturbed forest it will take hundreds of years to return to a typical rainforest ecosystem in the absence of fire. .6/

2. Impact on forest fauna

48. The impacts of forest fires on forest-dwelling species are determined by the frequency and intensity of fires. In Mediterranean area, in Portugal, it was found that the current more or less established fire regime probably contributed to maintaining the bird diversity at the landscape level (Moreira et al. 2001). In boreal forests, fire generally enhances moose habitat by creating and maintaining successional communities with young trees, bushes and abundance of grasses and herbs, and is considered beneficial to moose populations. The beneficial effects of fire on its habitat is estimated to last less than 50 years, with moose density peaking 20 to 25 years following fire (MacCracken & Viereck 1990, LeResche et al. 1974). Beaver, and deer are fire-dependent species, requiring the plant communities that persist following frequent fires. In forests of Minnesota, in the United States, caribou were once an important prey for grey wolves. Due to fire exclusion, the old-growth forested areas have increased, checking ungulate populations and consequently limiting grey wolf populations.

49. However, in forests where fire is not a natural disturbance, the impact on species can be very negative. The same goes for fires on sites where the natural fire regime is suppressed and flammable wood is unnaturally accumulated. The direct effect of fire on a great deal of forest fauna is death. Indirect effects of fires are far reaching and longer term and include loss of loss of shelter, food and territories. Loss of food-trees reduces the carrying capacity of the forest, causing overall decline in species that rely on fruits for food, a phenomenon especially true in tropical forests.

50. There are still few in-depth studies of the effect of fires on tropical rain forest biodiversity. Rabinowitz (1990) reports that burnt dipterocarp forest in Thailand is impoverished of small mammals, birds and reptiles, and that carnivores tend to avoid burnt-over areas. In Borneo, the orangutan suffered a 33 per cent decline in its population decline due to the 1997/98 forest fires (Rijksen and Meijaard 1999). The destruction of standing cavity trees as well as dead logs on the ground affects most small mammal species and cavity nesting birds (Kinnaird and O'Brien 1998). Finally, the extensive fires destroyed the leaf litter and its associated arthropod community, further reducing food availability for omnivores and carnivores (Kinnaird and O'Brien 1998). The loss of key organisms in forest ecosystems, such as invertebrates, pollinators and decomposers, can significantly slow the recovery rate of the forest (CIFOR 2001a). Following surface fires in the Brazilian Amazon, there was a decline in slow-moving animals, frugivores and much of the litter fauna (Nepstad et al. 1999).

51. Although boreal forest shows a good ability to adapt to fire, severe fires have had a significant negative impact on plant biodiversity, and local extinctions can occur. The number of critically endangered Amur tigers in large areas burned in 1976 in the Amur River basin in eastern Russia decreased markedly from 1972 to 1997 (Shvidenko and Goldammer 2001). Much of the area affected by the 1998 fires was also prime Amur tiger habitat. Estimates from the 1998 fires suggest that mammals and fish were badly affected.

6/ These forests were characterized by a multi-storey structure. In lightly disturbed forests, disturbances affected only the lower and middle storey; in moderately disturbed forests the lower and middle storeys were seriously damaged and the upper storey was opened to a limited extent; in heavily disturbed forests fire had destroyed the whole forest structure, from the lower storey up to the upper storey.

E. Activities in fire monitoring, control and prevention

52. Because increased international concern on uncontrolled forest fires, fire monitoring, control and prevention have been addressed by many organizations. As a part of its forestry programme, FAO provides information and technical assistance to its member countries and to the international community in the area of forest fire management and control. FAO's activities include data collection, dissemination and analysis, fire prevention and early warning, fire-fighting and control, post-fire rehabilitation and reconstruction and a number of operational activities. Recognizing the potential danger of fire as an agent of causing damage and loss of tropical forests, the International Tropical Timber Organization (ITTO) has developed guidelines on fire management in tropical forests to assist the parties to the International Tropical Timber Agreement in implementing forest-fire management programmes. Integrated forest fire management (IFFM), the core of the guidelines, is essential to control the damaging role of fire without unduly curtailing its beneficial aspects and to reduce the intensity of fires in cases of fire events. 7/ Since severe effects of fire on forests are also extended to biological diversity, the ITTO guidelines are equally relevant in the context of the conservation and sustainable use of biological diversity. The ITTO guidelines will be complemented by the FAO guidelines on fire management in temperate and boreal forests, which are under preparation.

53. The ITTO Project Fire Fight is working with WWF, IUCN, the Center for International Forestry Research (CIFOR) and other partners to identify policies and practical measures that help prevent uncontrolled forest fires. The Global Fire Monitoring Center (GFMC) was established in 1998. In the foundation stage it was envisaged that the GFMC might facilitate the formation of a mechanism that would support the United Nations in assessing countries in wildland fire emergency situations. The GFMC has systematically collected global fire statistics; to date, more than 70 nations have provided country reports with all kinds of fire data, including statistics. The GFMC fire documentation, information and monitoring system is accessible through the Internet. Through Working Group IV, on wildland fire, of the Inter-Agency Task Force under the International Strategy for Disaster Reduction, it is envisaged to establish an inter-agency and intersectoral forum composed of United Nations agencies and programmes, mechanisms of information and task-sharing in the field of reducing the negative impacts of fire on the environment and humanity.

F. Proposed sets of activities and options to address the negative impacts of forest fires

54. The direct and underlying causes of fire are complex and many, and there are no simple solutions to the problem. The most promising approach is towards community education and involvement in forestry. Very successful mechanisms for this have been developed through a mainly action-oriented approach with communities at a practical level.

55. There follows a set of generalized recommendations that address in part the underlying aspects for progress in controlling forest fires. They cover global, regional, national, government-sector, private-sector and community elements. While most will generate positive outcomes in most circumstances, not all activities are suitable for all countries.

56. *Assessment and reporting activities*:

7/ Integrated forest fire management (IFFM) can be treated in three specific phases: (i) pre-fire planning and fire prevention involving fire breaks, fuel-load control, weather monitoring, fire-risk assessment and early warning, equipment development, enforcement and surveillance, training in fire-fighting, research and extension, and infrastructure development, (ii) fire suppression, covering fire detection, quick communication; organization of fire crews; and (iii) post-fire rehabilitation and management, covering fire inventory and classification, and rehabilitation planning.

(a) To achieve a reliable and operational system for national, regional and global forest fire monitoring and reporting (Articles 5, 17 and 18 of the Convention on Biological Diversity) through:

(i) Collation and storage of comparable datasets on the occurrence, extent, socio-economy, and causes of forest fires worldwide should be done on inter-agency basis;

(ii) Establishment of national systems for forest fire monitoring and reporting;

(iii) Promotion and encouragement of participation of all stakeholders in providing data to the monitoring and reporting systems

(b) To identify the processes and environmental and socio-economic impacts of fires, particularly in vulnerable forest ecosystems, including tropical and boreal peatland systems, and tropical woodlands (Article 7 of the Convention on Biological Diversity) through:

(i) Identification of vulnerable forest ecosystems such as peatlands and woodlands, which are under threat from forest conversion and fire, their extent and characteristics;

(ii) Estimation of the contribution of the respective peatland forest and tropical woodland fires to global carbon emissions;

(iii) To assess more fully the impact of forest fires, in particular smoke and increased run-off and sedimentation due to clearance of vegetation by fire on aquatic and marine systems of tropical and boreal biomes

(c) To improve and facilitate the exchange of information on the impact and contribution of forest fires to global climate change (Article 18 of the Convention on Biological Diversity). This could include participation in international climate-change forums such as the United Nations Framework Convention on Climate Change and the Intergovernmental Panel of Climate Change, using, for example, the improved information developed above.

57. *Conservation and sustainable use of forest ecosystems*:

(a) To protect ecosystems that are vulnerable to forest fires and are important for conservation of national and global biodiversity (Article 8 of the Convention on Biological Diversity), through:

(i) Identification and development of appropriate fire management regimes for protected areas and biodiversity hot spots under most threat from fire;

(ii) Identification of effective practices to control and halt spread of accidental fires; and provision of the required resources for the implementation of these practices;

(iii) Recognizing local communities and multi-stakeholder interests in the use of forests, develop appropriate fire management plans in and around locations of high biodiversity value;

(iv) Recognizing that important forest biodiversity also exists in timber production forests or outside the protected area system, develop sets of standards for the preparation of environmentally sound and sustainable management plans (including fire management) that take account of biodiversity conservation and local community needs;

(v) The implementation of ITTO guidelines and known approaches in integrated forest fire management merits great attention and priority; as well as their further development at national levels and at ecosystem and land-use levels.

(b) To promote ecologically sustainable use of forests, including environmentally sound expansion of plantations, elimination of illegal logging, and improvement of timber harvesting practices to reduce organic debris to minimise unwanted fires (Articles 11 and 12 of Convention on Biological Diversity) through:

(i) Development of appropriate sets of standards for the development of plantations (timber, oil palm, rubber, including choice of tree species for plantations) taking full account of biodiversity conservation and local-community needs;

(ii) Development of a strategy to facilitate the adoption of improved timber harvesting practices by timber companies, local communities, and local governments

(c) To rehabilitate degraded or burned forest lands (Articles 8 and 10 of the Convention on Biological Diversity) through:

(i) Identification of methods and mechanisms to support local communities to develop remedial and income generating activities in areas degraded by fire;

(ii) Identification of best practices for forest rehabilitation and restoration in areas prone to fire.

58. *Enabling socio-economic environment to reduce occurrence and mitigate adverse effects of human-induced uncontrolled forest fires:*

(a) Training, education and public awareness in communities where fire is a major problem. (Articles 12 and 13 of the Convention on Biological Diversity):

(i) In many areas where local communities live in and around forests, fire is a major threat to health, livelihood and forest ecosystems. There is therefore a need to develop an awareness of both the negative and positive impacts of the use of fire in these areas;

(ii) Build awareness among policymakers, the public and the media as to the underlying causes of forest fires, their associated societal and economic costs and the importance of addressing these in a systematic fashion, for example, in environmental impact assessment and strategic environmental assessment procedures;

(b) To encourage community participation and involvement in fire management, prevention and suppression (Articles 8 and 10 of the Convention on Biological Diversity):

(i) Promotion of community involvement and education about forest and land fires;

(ii) Promotion and encouragement of policies that create and support community managed forests;

(iii) Mandating and equipping natural resources managers, in partnership with communities and relevant stakeholders to prepare and implement integrated fire management plans that promote a balance between fire prevention, response and restoration, and discourage strategies that rely too heavily on fire-fighting as the primary means to deal with forest fire;

(c) To analyse and change socio-economic factors favourable to uncontrolled forest fires:

(i) Identification of why policies and regulations have not been effective in reducing the large-scale catastrophic fires in 1997/98, such as in Indonesia, the far east of Russia, the United States of America, Amazonia and the Mediterranean region;

(ii) Development of a strategy to facilitate the adoption of improved timber harvesting practices by timber companies, local communities, and local governments;

(iii) Identification of the economic instruments and incentives that encourage improved fire management by land users;

(iv) Identification of the economic instruments and incentives that will lead to the adoption of rehabilitation and restoration programmes and activities in burnt forest land.

IV. UNSUSTAINABLE HARVESTING OF NON-TIMBER FOREST RESOURCES, INCLUDING BUSHMEAT AND LIVING BOTANICAL RESOURCES

A. Introduction

59. Non-timber forest resources are products of biological origin, other than wood, derived from forests, wooded lands and trees outside forests. Non-timber forest resources may be gathered from the wild, or produced in forest plantations, agroforestry schemes and trees outside forests. These resources are used across a wide spectrum of biogeographic, ecological, economic, social and historical circumstances across (and within) different continents and vegetation types.

60. Several million households world-wide depend heavily on non-timber forest resources for subsistence and/or income. Some 80 per cent of the population of the developing world use non-timber forest resources for health and nutritional needs. Women from poor households are generally those who rely more on such resources for household use and income. At a local level, non-timber forest resources also provide raw materials for large scale industrial processing. Some non-timber forest resources are also important export commodities. At present, at least 150 are significant in terms of international trade, including honey, gum arabic, rattan, bamboo, cork, nuts, mushrooms, resins, essential oils, and plant and animal parts for pharmaceutical products.

61. The harvesting of non-timber forest resources is not generally considered as including hunting and fishing. This usage is also followed here, with exception of the hunting of bushmeat. Bioprospecting of living biological material is not considered here in detail, since the level of threat and the context are rather different. Bioprospecting per se will not take large numbers of specimens, and it may only seldom have a broader impact on forest biological diversity. Similarly, issues of access and benefit-sharing of that material are also not addressed in the present note. 8/

62. In industrialized countries, the use of non-timber forest resources is often viewed as a marginal activity. In many developing countries, it is quite the opposite. Non-timber forest resources are in daily use throughout the tropics, commonly providing crucial resources to people. They are also locally

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8/ The Conference of the Parties established at its fifth meeting the Ad Hoc Open-ended Working Group on Access and Benefit, with the mandate to develop draft guidelines and other approaches on access to genetic resources and benefit-sharing. The report of the Working Group will be submitted to the Conference of the Parties for consideration at its sixth meeting.

important in many areas in Northern Eurasia and North America (e.g. Chamberlain et al. 1998, Chamberlain et al. 2000, Filipchuk 2001, Saastamoinen et al. 1998).

63. In the past, these resources were traditionally used for subsistence. More recently, many non-timber forest resources are harvested unsustainably, partly as a result of easier access to remote forests because of new road networks, but mainly because of an increased demand for these products. The ecological effects of unsustainable use are exacerbated by the on-going deforestation and fragmentation of forests. There is an urgent need for action to halt and prevent further over-exploitation.

64. Section B of the present chapter describes the occurrence and harvesting of non-timber forest resources and the identification of main potential impacts of their unsustainable harvesting on forest biological diversity, while section C presents some proposals for actions to halt, and prevent further overexploitation of these resources.

B. Occurrence and harvesting of non-timber forest resources and its impacts on forest biological diversity

1. Variety of plants and animals harvested

65. Non-timber forest resources include a variety of plant and animal products (see Table 1). In *terra firme* forest in Amazonia, for example, Prance et al. (1992) recorded that 78.7% of tree species were used by the Ka'apor and 61.4% by the Tembe indigenous peoples. In Indonesia, Siswoyo et al. (1994) list 1260 species of medicinal plants being sold, many wild-collected species from forests. These examples show that the number of plants harvested for non-timber forest resources is very high in the tropics, and it is also relatively high in many temperate areas (e.g. Chamberlain et al. 2000). In boreal regions the variety of plants used as non-timber forest resources is limited in number, but these plants and fungi are, however, often widely distributed and can produce high yields, like many berries and mushrooms (Saastamoinen et al. 1998, Filipchuk 2001).

66. A great deal of the bush meat consumed for subsistence comes from small game (insects, worms, small reptiles, eggs, birds, rodents), occasionally larger animals, like antelopes, primates and wild pigs. Those that are entering local trade by hunters come from a relatively small number of large-bodied species, such as ungulates and primates (Bennett and Robinson, 2000), although a much wider variety of species are used to some extent depending on local circumstances. In Sarawak, Malaysia, three ungulate mammal species comprised 80 per cent of biomass hunted (Bennett et al., 2000), although at least 26 mammal species, 12 bird species and five reptile species are regularly eaten. Many insects, incidentally, are used as food around the world, and may even be farmed as food.

Table 1. Indicative list of non -timber forest resources *

Category	*Important products (lists not exhaustive)*

* Modified from FAO (1999, – see also http://www.fao.org/docrep/V9631e/V9631e00.htm#Contents). Fodder for animals and plant material for shelter are not included.

Category	*Important products (lists not exhaustive)*
Food products	*Nuts*. Brazil nuts, pine nuts, malva nut, walnuts, chestnuts *Fruits*. Jujube, sapodilla, ginkgo, bush mango *Berries*. Cranberry, blueberry, raspberry, cloudberry (many Ericaceae and Rosaceae) *Edible fungi*. Morels, truffles and other mushrooms *Vegetables*. Bamboo shoots, reindeer moss, various “green” leaves, palm hearts *Starches*. Sago Birds’ nests *Oils*. Shea butter, babassu oil, illipe oil Maple sugar, Birch sap
Spices, condiments and culinary herbs	Nutmeg and mace, cinnamon, cassia, cardamom, bay leaves, oregano, etc.
Industrial plant oils and waxes	Tung oil, neem oil, jojoba oil, kemiri oil, akar wangi, babassu, oiticica and kapok oils. Carnauba wax.
Plant gums	*Gums for food uses*. Arabic, tragacanth, karaya and carob gums. *Technological grade gums*. Talha and Combretum gums.
Natural plant pigments	Annatto seeds, logwood, indigo.
Oleoresins	Pine oleoresin Copal, damar, gamboge, benzoin, dragon's blood, and copaiba oil. Amber
Fibres, canes and flosses	*Fibres*. Bamboo, rattan, xateattap, aren, osier, raffia, toquilla straw products, cork, esparto, Erica and other broom grasses. *Flosses*. Kapok.
Vegetable tanning materials	Oak, mimosa, chestnut and catha/cutch.
Latex	Natural rubber, gutta percha, jelutong, sorva and chicle.
Insect products	Natural honey, beeswax, lac and lac-dye, mulberry and non-mulberry silks, cochineal, aleppo galls, kermes
Incense woods	Sandalwood, gaharu.
Plant insecticides	Pyrethrum, Derris, Medang and Peuak Bong
Medicinal plants	Around 5000 to 6000 botanicals entering world market every year
Living botanical resources	Collecting living plant material for bioprospecting, plant breeding, research etc, collecting Orchids, Bromelids, Cacti and other succulents, cycads, insectivorous plants, bulbs etc. for horticulture, greenery or trade
Wood-based products	Handicraft, carving, containers
Floral, decorative products	Very many plants or their parts (flowers, fruits)
Animals and animal products	Ivory, trophies, bones, feathers, butterflies, live animals and birds, bushmeat, etc.

67. In spite of wide use of many plant and animals, little is known about tropical plant and animal species, let alone their population biology, standing stocks or yields. Because of the diversity of tropical ecosystems and uses of non-timber forest resources, our limited scientific knowledge and the ecological

and taxonomic insights held by local and indigenous people, it is recommended that more use should be made of folk taxonomists. Where formally trained taxonomists are not (and unlikely to become) available, local folk taxonomists can be remarkably effective. 9/ The greatest contribution by folk taxonomists will probably be in the inventory and population biology of useful species such as edible or medicinal plants or animals. There is a need for collaboration between folk taxonomists and professional taxonomists, for example in order to check taxa identified on local and national level for taxonomic consistency at a regional level.

2. Valuation of non-timber forest resources

68. Despite the importance of non-timber forest plant resources, their value is rarely taken into account in land use planning. Economic values of these products and the services they provide are only occasionally taken into account in assessing gross domestic product. These omissions need to be corrected, as non-timber forest resources make particularly significant contribution to household incomes of the rural poor.

69. At the local level, available studies suggest that economic values of non-timber forest resources (net values) range from a few dollars to up to about $100 per hectare per annum (UNEP/CBD/SBSTTA/7/INF/3). Lampietti and Dixon (1995) suggested a "default" value of around $70 per hectare, and Pearce (1998) has suggested $50. Cash income from the sale of non-timber forest resources, such as bushmeat, can be very variable, even for the same resource category. Earnings vary from a few dollars for *ad hoc* sales to several thousand dollars per year per household (UNEP/CBD/SBSTTA/7/INF/2, WSPA 2000).

70. The value of the non-timber forest resources often accounts for 30-60 per cent of local community household income (UNEP/CBD/SBSTTA/7/INF/3). In general, returns to labour from non-timber forest resources sales are usually higher than the average local agricultural wage, with income usually higher for externally marketed products. Subsistence values are often also high, particularly for poorer rural households. In Zimbabwe, for example, Cavendish (1997) calculated that these subsistence ("non-market") values contributed 35 per cent of total household incomes. This perspective demonstrates the critical importance of non-timber forest resources as a means of income support. It also underlines the role of non-timber forest resources in poverty alleviation.

71. Starchy staple food from a few species of cultivated plants form the bulk of people's food in the tropics. Bushmeat commonly provides an important protein source, and gathered plant foods are an important source of dietary supplements. Even where there has been a change from a hunter-gatherer lifestyle to pastoralism or agriculture, hunting and gathering remain important to a high proportion of rural households. Wild plant foods are well known from studies in Africa, Asia and Latin America to be a valuable source of these nutrients deficient in starchy staple diets.

72. The high social and cultural values linked to foods and medicines are a reflection of the value placed on non-timber forest resources. Even airfreight is used to transport edible and medicinal plants, regionally or internationally, to meet culturally driven demand, as can be seen from the international trade in Chinese traditional medicines. Demands for traditional medicine continues in the urban environment even if western biomedicine is available. Non-timber forest resources can also be considered as luxury. Urban consumers typically pay more for chimpanzee meat, for example, than for beef or chicken. There

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9/ The role of local people in tropical taxonomy initiatives has also been recognized in a number of successful projects in, for example, India, Indonesia, Costa Rica and Brazil (UNEP/CBD/SBSTTA/7/INF/2) are also some verified reports of bushmeat from African rain forests on the menu of restaurants in Europe or United States (WSPA 2000).

73. Local gatherers often get a low and highly variable price for unprocessed plant material at the start of the complex marketing chains from rural gatherers harvesting wild species to urban consumers. Low prices also mean that few slow growing species are cultivated and that cultivation for profit is restricted to a small number of high priced and/or fast growing species. One consequence of low prices to harvesters can be overexploitation and conversely, increased income through value-addition and processing can provide an incentive to decrease harvest levels. 10/

74. The potential of industrial development of foodstuff products of forest origin is remarkable, and their harvesting and processing give many possibilities to labour-intensive small-scale enterprises. Peters (1992) has suggested, giving a number of examples from Amazonia, that where market-oriented extraction of non-timber forest resources is the objective, then it would be best to focus on tropical forests dominated by only one or two useful species, rather than species-rich ecosystems. There has been a move in development projects to support in-country processing of non-timber forest resources (as well as timber itself). This can be seen in the bioprospecting work associated with INBio in Costa Rica, where the institute now has its own processing laboratory, and in the rattan industries in the Far East. Income is thus increased at the country level and more employment found in country.

3. Underlying causes and unsustainable harvesting of non-timber forest resources

75. The same underlying causes that apply to deforestation are also largely responsible for unsustainable harvesting of non-timber forest resources. Understanding of what drives deforestation (Kaimowitz and Angelsen, 1998) and resultant policy change are directly relevant to sustainable use of non-timber forest resources. Population growth, urbanization and the shift from subsistence to cash economy increase consumption of many non-timber forest resources, such as bushmeat. Rural people, moving from a subsistence lifestyle to a cash economy, have relatively few options for generating income. Wild and naturalized plants provide a “green social security” to billions of people in the form of low-cost building materials, income, fuel, food supplements and traditional medicines. Bushmeat from larger animals is important as a protein source in western and central Africa.

76. This transition has been enhanced through easier access to unmanaged forests as a result of development projects or logging activities. Transport systems are reaching further into remote, resource-rich regions, catalysing settlement, and forest and woodland clearing. The result is a loss of supplies of wild harvested species as habitat declines as well as increased trade in bush meat and wild plant species. Improved transport networks strengthen also the link between rural resources and urban demand. As cities grow, the markets within them exert a stronger pull on rural resources. As a result, urbanization has tended to increase rather than reduce the demand for wild plant resources, stimulating a commercial trade that encourages over-exploitation (UNEP/CBD/SBSTTA/7/INF/2), in addition to changing the type of species of non-timber forest resources being commercialized (usually a higher consumption of luxury non-timber forest resources goods for the affluent urban classes).

77. Cultural systems are even more dynamic than biological ones, and the shift from a subsistence economy to a cash economy is a dominant factor among all but the most remote of peoples. In many parts of the world, traditional conservation practices have been weakened by cultural change, higher

10/ For this reason, for example, Shankar et al. (1996) have recommended with successful results an alternative flow of amla (*Phyllanthus emblica*) fruit in India from the forest source area to the Indian consumer, improving economic benefits to harvesters as a means of improving household income while reducing overharvesting of fruits.

human needs and numbers and a shift to cash economies. There are an increasing number of cases where resources which were traditionally conserved, or which appeared to be conserved, are being overexploited today. In the most extreme cases, "islands" of remaining vegetation, usually created by habitat loss through clearing for agriculture, then become focal points for harvesting pressure, and sites of conflict over remaining land or resources.

78. Land conversion and other land-use changes, and unsustainable forest management can have very adverse effects on non-timber forest resources. For these reasons, Wilkie et al. (2000) highlight the need, through coordinated land-use and infrastructure planning, to plan roads in a way that maximizes local and national economic benefits while minimizing the negative effects road construction has on biodiversity.

4. Impact of unsustainable harvesting on forest biological diversity

79. Traditional harvesting of non-timber forest resources has mostly taken place in landscapes changed by people as a result of farming, fire or livestock production, even where human population densities are very low. In the Brazilian Amazon, for example, at least 12 per cent of *terra firme* forest is an anthropogenic result of slash-and-burn agriculture, human settlement and plant domestication (Balee, 1989). In all savannah woodlands, fire is a frequent source of disturbance. Direct use of resources is thus superimposed upon the effects of natural and/or anthropogenic disturbance. In some cases disturbances enhance species populations and in others, diminishes them. Many species of bamboo, thatch-grasses, edible leafy greens and sources of bark fibre are favoured, because they are light-demanding plants whose populations increase in response to disturbance.

80. Vulnerability or resilience to harvesting is influenced by level of demand and by common biological characteristics: life form (plants) or body size (animals), growth rate, reproductive biology, geographic distribution, habitat specificity, population density, etc. (Cunningham, 2001). The effects of harvesting on a plant population depend on what part of the plant is harvested and on the quantity, intensity and frequency of harvesting. Most harvesting has some effect, but extirpation has been - infrequent and extinction even rarer, usually as a product of habitat destruction coupled to commercial harvesting of restricted range species.

81. In the past, under subsistence demand, harvesting of plant-based non-timber forest resources rarely resulted in severe species-specific overexploitation. At present, however, species specific overharvesting of some plant and animal species is becoming a significant factor as habitats shrink and demand for valued but vulnerable species increases. Substantial proportions of some of the world's most useful plant families are currently threatened either habitat loss or species-specific overexploitation (or a combination of the two) (UNEP/CBD/SBSTTA/7/INF/2). For example, the extent to which many plants or their parts are collected for export as ornamentals can have serious effects. Concern over rising levels of exploitation of living plants has led to listing of many orchids and cacti in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

82. The wildlife biomass of larger mammals in tropical forests is generally low. Wildlife hunting may be sustained but only where human population densities are low. Based on a recent review of studies on hunting in tropical forest, Bennett and Robinson (2000) suggest that for people depending exclusively on wild meat, hunting may not be sustainable if human population densities exceed one person per square kilometre. Where people shift from subsistence to a cash economy, frequency and intensity of harvesting or hunting change rapidly, for example in response to commercial demand stimulated by increased access (e.g. road construction for logging). The bushmeat trade (Bennett and Robinson, 2000) as well as some rattan, craft, decorative and medicinal plant species all provide examples of this situation (Cunningham and Milton, 1987; Nantel et al, 1996).

83. In cases where whole plants are harvested the effects of reduced population size may be genetically significant. For a small number of especially valuable species, entire populations have already been lost or severely depleted through over-exploitation. Examples include aquaje palm (*Mauritia flexuosa*) in Peru, *Aquillaria* (Agarwood) species in south and south-east Asia, sandalwood species in the south-west Pacific and rattan species in parts of south-east Asia. Large-scale harvesting of reproductive structures (flowers, fruits and seeds) will directly reduce the effective size of the pool of reproductive parents and reduce genetic diversity in subsequent generations. 11/

84. Yields from wild populations are often overestimated, particularly if the effects of stochastic events in the demography or in the ecological factors in the environment of the target populations are taken into account. As a result, commercial harvesting ventures based on wild populations can be characterized by a situation where initial harvests are followed by declining resource availability. Harvested populations in turn need to be viewed in terms of abundance, distribution and response to disturbance at the landscape level (Cunningham, 2001). A seemingly low-impact use, such as harvesting of fruits, may have a high long-term impact on populations of some species, either because of long-term impact on seedling recruitment or because fruit collection involves tree felling.

85. In recent years, declining populations of many mammal and bird species because of bushmeat hunting has been reported (WSPA 2000, CITES 2000). The bushmeat trade is today having a profound and unsustainable impact upon Central and West African wildlife populations. In the past decade, demand has pushed the trade from the subsistence basis to one of increasing commercial values. Many species of ungulates and primates are included, such as the chimpanzee, bonono and gorilla. Gorilla and bonono are recognized as endangered (some subspecies of gorilla as critically endangered) and chimpanzee as vulnerable. They all are listed in the appendix I of CITES. If Governments and the international community do not respond vigorously and comprehensively to the unsustainable bushmeat hunting, most endangered medium and large sized mammals, and many endangered bird and reptiles, will be extinct in these areas within a few decades (WSPA 2000).

86. Overexploitation of large animals may have wider influences on forest biological diversity. For example, many birds and apes, including great apes, may be considered as keystone species in local forests as they are predominantly fruit eaters and play important role in seed dispersal of many large-fruit plants. A recent study (Pacheco and Simonetti 2000) revealed that the local extinctions of spider monkeys through bush meat hunting can lead to genetic consequences in the rainforest tree *Inga ingoides*, 12/ because monkeys as main dispersal vector of fruits are responsible for maintaining a thorough genetic mix in the tree population.

87. Periodic assessment of the extent and rate of loss (or expansion) of habitat at a landscape level using aerial photographs or satellite images are a common, cost-effective way to monitor the success or failure of conservation programmes, but they do not give the full-picture. Forest or woodland cover may not change at all — but underneath the canopy, populations of high value, vulnerable plant and animal species can be disappearing due to species specific overexploitation: the "empty forest" phenomenon described for wildlife. This situation is rarely taken into account in protected area management. For these

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11/ Selective commercial harvesting of fruits, nut and oilseeds can also adversely affect the genetic composition of the tree species and populations being utilized. Harvesting from mainly better fruit genotypes may result in a population dominated by trees of marginal economic value with much less value as a genetic resource.

12/ Pacheco and Simonetti (2000) found that there was less genetic variation in the seedling population around parent trees when the monkeys were absent than they were present reasons, monitoring at a large spatial scale needs to be combined with monitoring of a high value "indicator" species at a population level to give a comprehensive picture.

5. *Research activities*

88. Over the two past decades, there has been a marked growth in national and international interest in non-timber forest resources, both by researchers and policy makers. This trend is reflected in an equivalent growth in a wide range of international activities related to different levels of research, training or the dissemination of research results on non-timber forest resources. The non-wood forest products programme of the FAO Forestry Department, the European Tropical Forest Research Network (ETFRN) and the International Union of Forest Research Organizations (IUFRO) are international networks linking various stakeholders, and especially scientific community to ensure more efficient communication on non-timber forest resources. 13/ The International Tropical Timber Organization (ITTO) has implemented numerous projects to assist member countries in promoting sustainable management and use of tropical non-timber forest resources. The ITTO Criteria and Indicators for Sustainable Management of Natural Tropical Forests include the conservation and maintenance of biological; diversity, focusing on ecosystem, species and genetic diversity. The African Ethnobotany Network (AEN), South and South East Asian countries Non-Timber Forest Products Network (SEANN) and Tropical Agricultural Research and Higher Education Center (CATIE) are examples on regional networks. There are also thematic research programmes that focus on taxonomic (e.g. bamboos, palms, rattan, fungi) or use categories (medicinal and aromatic plants, spices), mostly as part of IUFRO's activities, and international research initiatives of many non-timber forest resources and related themes, for example, through the centres members of the Consultative Group on International Agricultural Research (CGIAR), international conservation agencies, botanical gardens and universities.

C. Proposed options to mitigate the negative impacts of unsustainable harvesting of non-timber forest resources on forest biodiversity

89. Whether the use of non-timber forest resources (including bushmeat and living botanical resources) is considered from the perspective of local livelihoods or conservation, species loss through overexploitation benefits neither local communities nor conservation in the long term. Unrestricted access to valued but vulnerable species may provide a high initial harvest, but this will merely be a temporary, and will be followed by loss of local self-sufficiency and higher effort or prices to get the species elsewhere.

90. Sustainable management of non-timber forest resources sits at the confluence of a number of articles of the Convention on Biological Diversity addressing conservation and sustainable use. Simplistic, "one-size-fits-all" policies can do more harm than good and should be avoided. Policies for conservation and harvesting, as well as their implementation practices, have to be tailored to local ecological, economic, cultural and political circumstances.

91. *Assessment and reporting activities*:

13/ The rich FAO literature is available on the World Wide Web at: http://www.fao.org/forestry/FOP/FOPW/NWFP/nwfp-e.stm, http://www.fao.org/forestry/FOP/FOPW/NWFP/pubser-e.stm, and " Non-wood forest products for rural income and sustainable forestry" at http://www.fao.org/docrep/v9480e/v9480e00.htm. In addition FAO has on its website under the Forest Resource Assessment a section on "Non-Wood Forest Products" with country profiles, detailing the importance of NTFR at the country level, as well as a global summary: http://www.fao.org/forestry/fo/country/index.jsp?geo_id=19&lang_id=1.

(a) Recognize and strengthen the role of local people in inventory, research, monitoring and impact assessment processes (Article 12 of the Convention on Biological Diversity) to complement ongoing work by professionals and researchers:

(i) Folk taxonomy elements in the work programme of the Global Taxonomy Initiative, approved by SBSTTA at its sixth meeting and to be submitted to the sixth meeting of the Conference of the Parties, should be strengthened, and the planned activity 16 could be directed at inventory, research, monitoring and impact assessments;

(ii) There is a need for training young professionals and the staff of agencies responsible for the management of non-timber forest resources and wildlife resources to work effectively with the local harvesters and their communities, private owners and those working for commercial enterprises. This will require technical and scientific cooperation (Articles 18 and 25 (c) of the Convention);

(b) Appropriate and economically viable monitoring systems should be developed and established at the landscape level (remote sensing, aerial photograph analysis) and local level (indicator species) (Article 7 of the Convention). Involvement of local people in this process, through both mapping and monitoring should be considered. Efficient systems for data storage, analysis and the return of results to local people should accompany this process;

(c) Integrate non-timber product uses into forest inventory and management. The opportunity for better coordinated inventory and management of non-timber forest resources to avoid wastage should influence the choice of natural forest logging systems and how these influence non-timber forest products. Although many tree species have multiple uses aside from timber, this is rarely taken into account in forest inventory or management. Many forest non-timber species and timber species require often conflicting silvicultural treatments, which makes the planning of long-term management important.

92. *Conservation and sustainable use of non-timber forest resources.*

(a) To achieve a balance between conservation and sustainable use of non-timber forest resources, including bushmeat and living botanical resources, there is a need to establish and consolidate protected area networks and establish and maintain ecological corridors (Article 8 (a) of the Convention):

(i) Identification and legal protection of currently unprotected sites that are a priority for conservation of forest biological diversity and ecosystem processes and, where necessary, increase of the effectiveness of existing protected area management;

(ii) Putting in place land-use mosaics favourable to the conservation goals of the adjacent protected areas. The form will vary with the social, political and economic circumstances, but could include conservancies, “land care” groups, multiple-use zones, co-management areas or indigenous production forests;

(iii) Land-use and infrastructure planning (roads, new settlements) need to take into account protected areas, their adjacent conservancies or co-management areas and the requirements for maintaining viable populations of valued- but vulnerable species;

(b) Highlight in collaboration with CITES the disastrous consequences of commercial bushmeat hunting and request Governments and industry to take responsibility for its limitation:

(i) International development agencies should ensure that all development projects undergo an environmental impact assessment prior to approval to ensure that forests, wildlife, indigenous peoples and local communities are not adversely affected;

(ii) All future forest concession agreements should include specific management plans to conserve wildlife and the means to achieve those objectives;

(iii) Timber companies should adopt a code of conduct aimed at minimizing the impact of hunting in logging concession and work with local people to verify such progress, and seek independent certification of their timber products;

(c) Conservation through cultivation or farming of wildlife that is economically viable and on a sufficient scale to take the pressure off wild stocks. When wild harvest is often unsustainable, particularly under high demand, cultivation or farming can be a more sustainable, practical and cheaper option:

(i) Medicinal-plant domestication programmes need to be expanded, taking fuller advantage of the genetic and chemical diversity within species over wide geographical areas in parallel to on-going programme for managing the species in its wild habitat;

(ii) Developing new alternative sources of protein for people using bush meat;

(d) *Ex situ* conservation needs to be developed for some high value, high vulnerability species (Article 9 of the Convention). *Ex situ* gene banks should be developed, with commercially harvested, habitat specific, phylogenetically distinct taxa being an important priority.

93. *Enabling socio-economic environment for conservation and sustainable use of non-timber forest resources*:

(a) Ecosystem and harvested/hunted population management planning should take place through a process of consultation that takes relevant scientific, local and indigenous knowledge into account and be based on an understanding of the social, economic, ethical, religious and political factors that either encourage resource conservation or lead to resource depletion. Efforts should include support to local or indigenous people trying to protect their biological and cultural heritage from incursions such as industrial logging, large dams or industrial-scale agriculture;

(b) Raise importer, exporter and retail buyer awareness: Importers and consumers in importing countries need to become aware of whether the products they consume are harvested sustainably or not, and bear some responsibility for sustainable resource management:

(i) Programmes that raise awareness about the "ecological footprint" of long-distance trade of non-timber forest resources from developing to developed countries;

(ii) Existing certification programmes in forestry and agriculture for food products should be expanded as to include the wide variety of non-timber forest resources gathered in sustainable managed forests.

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